TERESTRIAL LASER SCANNING TECHNOLOGY USED IN THE FIELD OF SHIPBUILDING

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***Abstract:** Shipbuilding has as its basis fundament the accuracy in all its constitutive aspects and designing and dimensioning of ship subassemblies make no exception. The dimensional control of these subassemblies in different stages of production is very important in terms of production profitability of the vessel. In addition, the accuracy control in different stages is critical because these subassemblies will form the base for hull production. Currently, in shipbuilding, are used various instruments and software applications to achieve three-dimensional control such as high precision total stations, laser tracker systems type or laser scanning systems that allow fast and accurate collection of data and information. For this purpose there was conducted a study which is based on rigorous control of the dimensions of a ship subassembly using Leica Geosystems ScanStation2 HDS technology.*

***Keywords**: LaserScanner, 3D measurements, shipbuilding, dimensional control.*

1. Introduction

In engineering fields such as shipbuilding, aircraft and so on, there are many situations where it is necessary to perform measurements in three-dimensional system which must satisfy the accuracy requirements required in the production process. Starting from simple measurements of distances up to complex ones, such as micrometer control of deformations or symmetry, all of measurements and analysis of geometric shapes are part of a process known generically as dimensional control.

Technical progress allows efficient and powerful works and due to, more and more demanding requirements, even the smallest details have to be conceived, designed and implemented with care. However, at the manufacturing stage, production of materials, assembly and their combination may have differences from the original realized in the design phase. Any deviation from the original project must be analyzed carefully at the design stage by introducing manufacturing tolerances, which is fundamental in order to anticipate potential functionality problems in subunits production and in assemblage process.

From engineering point of view, a vessel is composed from several parts with different features and sizes which interact and influence the overall performance and efficiency of the ship. A small error in design or manufacture can cause functional problems or in some extreme cases, risks to human health and the environment. In order to prevent these problems or risks, classification societies and other international organizations have developed standards for the shipbuilding workflow known under IACS 2008 and SSC 2007 names.

Checking operations require careful planning of measuring operations since required accuracies have to be very high and, in general for such measurements are used special instruments such as total stations and laser trackers that can provide an accuracy of 0.1mm at a distance of 10 m. In some cases systems are used, that offer high densities of points as terrestrial laser scanners, for a better analysis of the dimensions and strains, when it comes to larger objects which must be measured in small spaces or disadvantageous environmental conditions.

2. Theoretical review

2.1 Classification of laser scanners and areas of interest

❖ **Clasification of laser scanners**

A three-dimensional laser scanner is a tool for automatically and systematically collection of 3D data, with a high frequency (hundreds or thousands of points per second) and delivers the spatial coordinates in real-time of defining points of a land surface or object in a raw point cloud which shows the spatial geometry of the scanned object. The current laser scanning technologies can be classified into two categories, namely static and dynamic.

a) In **Static Scanning** category are included instruments which are installed in a fixed position throughout the duration of data acquisition (Figure 1). Also known as **Terrestrial Laser Scanners**, these instruments record the spatial position of points by measuring horizontal and vertical angles and distance between them and the station point. Some of the advantages of this category are: high precision of the results, high density of points, low cost of measurements etc.

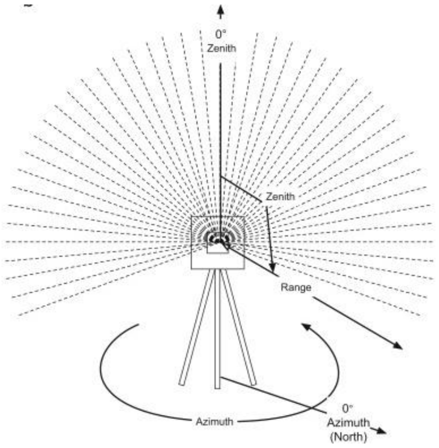


Fig. 1. Terestrial Laser Scanning – TLS

b) Regarding **Dynamic Laser Scanning**, the sensor is mounted on a mobile platform which can be a plane (**Aerial Laser Scanning**) or vehicle (Figure 2). These systems are more complex than terrestrial laser scanners and they work most often in combination with positioning systems (GPS - Global Positioning System or INS - Inertial Navigation System). Accuracy and density of points is appreciably reduced comparing terrestrial laser scanners, but the purpose of these systems is to measure large areas of land in a minimum time of work.

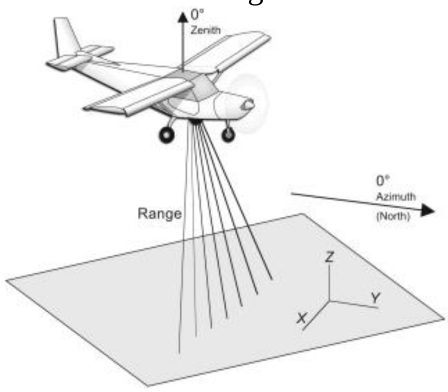


Fig. 2. Aerial Laser Scanning – ALS

❖ **Areas of interest of terrestrial laser scanning**

Due to the advantages such as: measurement without contact, high precision, long range, rapid acquisition of information etc., laser scanning is currently used in the following major areas:

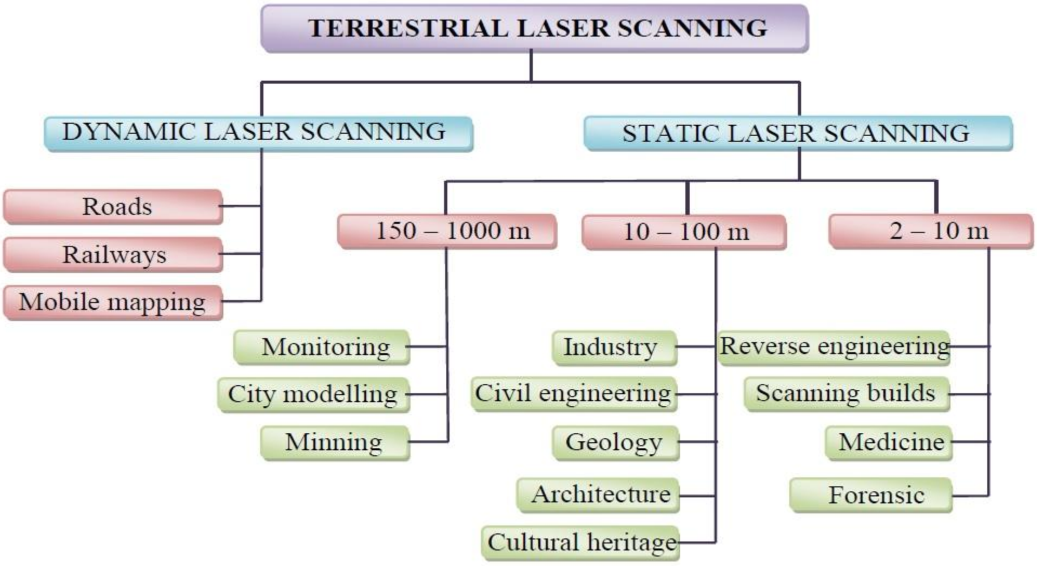


Fig. 3. Areas of interest of terrestrial laser scanning

2.2 Hardware and software description

For data acquisition has been used a scan tool represented by terrestrial laser scanner Leica ScanStation 2 and related accessories. The assembly formed by the laser scanning system is described in figure 4.

As structure, it consists of two major parts: the tribrach and the scanner body. The tribrach represents the bottom component that secures the device on the tripod, connects the scanner to the laptop. The upper part of scanning device represents the system itself, which is encased in a hard plastic housing that has two windows in order to allow the laser beam to scan.

a) Handle
b) Top window cover
c) Front window cover
d) LED indicators
e) Connector for power supply (2)
f) Ethernet connector
g) Top window/front window
h) Circular level
i) QuickScanTM button
j) Lock knob
k) Table stand

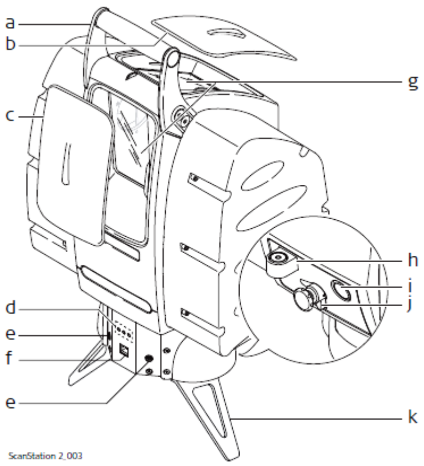


Fig. 4. Leica ScanStation2 and its components

Specifications of ScanStation2 relates primarily to its field of view. The angles **a** and **b** in figure 5, together with the horizontal rotation angle of 360 ° forms a field of view 360^{o} x

270^o. The axis noted with 0^o0^o represents the horizontal axis and the one noted with 90^o represents the vertical axis (zenith).

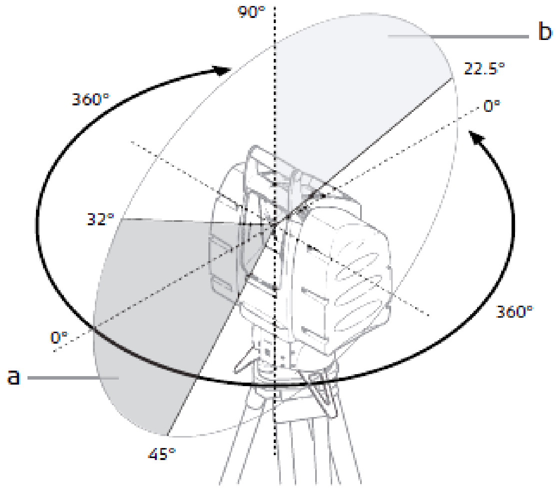


Fig. 5. Leica ScanStation2 field of view

In Table 1 are described technical specifications of the system used in this paper, Leica Geosystems ScanStation2:

Table 1. Leica ScanStation2 – Techinical Specifications

Technical specifications	
General data	
Instrument type	Pulsed, dual-axis compensated, very-high speed laser scanner, with survey-grade accuracy, range, and field-of-view
User interface	Laptop or Tablet PC
Scanner drive	Servo motor
Camera	Integrated high-resolution digital camera
Dimensiuni	265 x 370 x 510 ***(l x L x Î)*** [mm]
Greutate	18,8 kg nominal
System Performance	
Accuracy of single measurement	Position: 6mm, Distance: 4mm Angle (horizontal/vertical):12"
Modeled surface precision/noise**	2 mm standard deviation
Target acquisition	2 mm standard deviation
Dual-axis compensator	Selectable on/off**,** Resolution 1"
Laser Scanning System	
Type	Pulsed; proprietary microchip
Colour	Green, Laser Class 3R (IEC 60825-1)
Range	300 m @ 90%; 134 m @ 18% albedo
Scan rate	Up to 50,000 points/sec
Scan resolution	Spot size From 0 - 50m:4mm (FWHH - based); Fully selectable vertical/horizontal 1point/mm Max 20.000 points/horizontal Max 5.000 points/vertical
Field-of-view (per scan)	Horizontal 360° (maximum) Vertical 270° (maximum) Aiming/Sighting Optical sighting using QuickScan™ button
Scanning Optics	Single mirror, panoramic, front and upper window design; Environmentally protected by housing and two glass shields
Communications	Static Internet Protocol (IP) Adress
Level indicator	External bubble and via laptop

Direct Export Formats	ASCII point data (XYZ, SVY, PTX, TXT), DXF Leica's X-Function DBX format, Land XML, PTZ

The communication with the instrument takes place through an software application, specially designed for this purpose by Leica Geosystems. Leica Cyclone performs the control of device during the field work but also represents modeling software for processing the recorded data. It is used for operating the Leica scanners that use the principles of pulse and phase and processes point clouds resulting from measurements taken with them.

Hardware requirements for the program are very limited but this refers only to data acquisition process, where the laptop or PC are not necessary required. Once the data acquisition was performed, the modeling process becomes unwieldy and consume many resources on the computer. Thereby, for data acquisition has been used a Dell XPS laptop and for data processing a HP Pavilion PC, both being very efficient at the moment.

Cyclone program offers a multitude of options for data recording and three-dimensional modeling through some basic modules of the same software:

❖ Cyclone-Scan: module used to record data in the field, by controlling the instrument and setting scanning parameters.

❖ Cyclone-Register: uses a series of systematized steps for Registering multiples point clouds obtained from multiple scans.

❖ Cyclone-Survey: gives the user basic functionality to extract and measure information out of the rich point cloud.

❖ Cyclone-Model: gives the user the full functionality of Cyclone. The user is able to extract and measure features and to create a 3D Model out of the PointCloud.

❖ Cyclone-Publisher: allows exporting the final project or work in a format that can be viewed without the software Leica Cyclone, through Leica TruView viewer into a website.

2.3 Measuring principle of Leica ScanStation 2

Leica ScanStation 2 use the time-of-flight (TOF) measurement principle (Figure 6) which is based upon the principle of sending out a laser pulse and observing the time taken for the pulse to reflect from an object and return to the instrument.

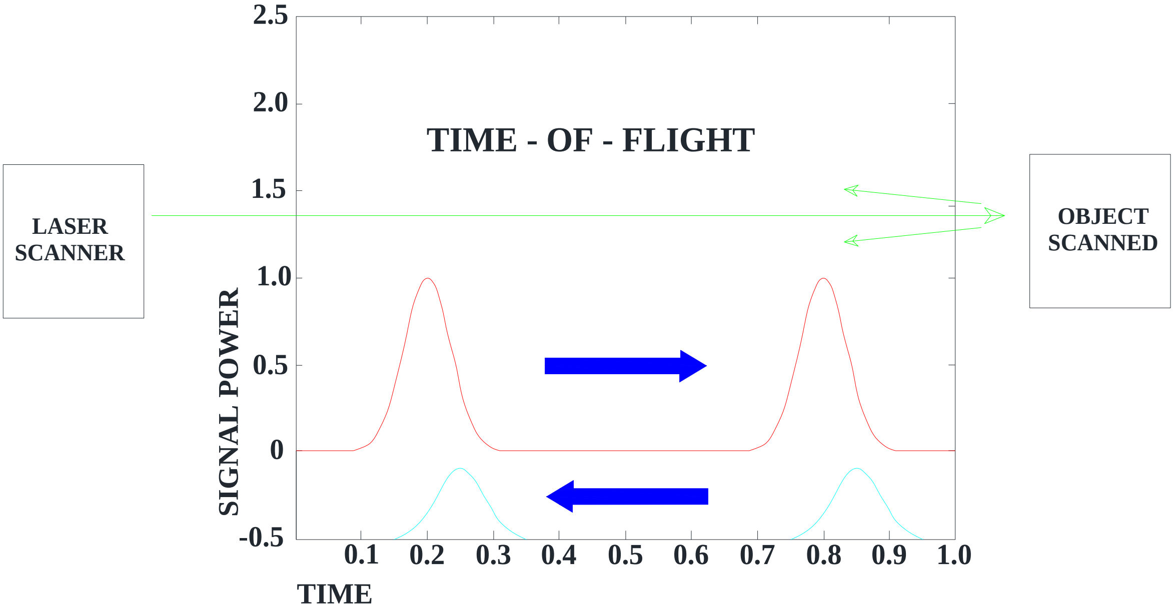


Fig. 6. Working principle of time-of-flight 3d laser scanners

Advanced high-speed electronics are used to measure the small time difference and to compute the range to the target. The range is combined with high-resolution angular encoder measurements (azimuth and elevation angles) to provide the three-dimensional location of the point. In this way, the distance is calculated using the equation:

$$D = \frac{c_0 \cdot t}{2},$$

where:

D – distance (m);

t – time taken for the pulse to reflect from an object and return to the instrument (s);

c_0 – speed of light in vacuum (m/s).

3. Results and conclusions

In order to relieve the advantages and disadvantages of using a scanning system in shipbuilding, was performed a scan task of a subassembly, part of an under construction vessel at Damen Shipyards Galati (Figure 7).

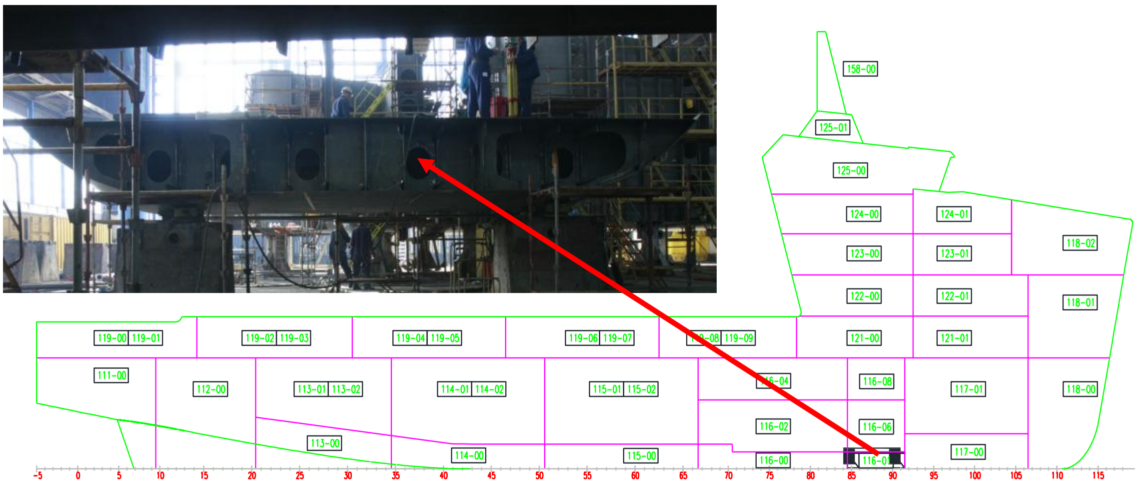


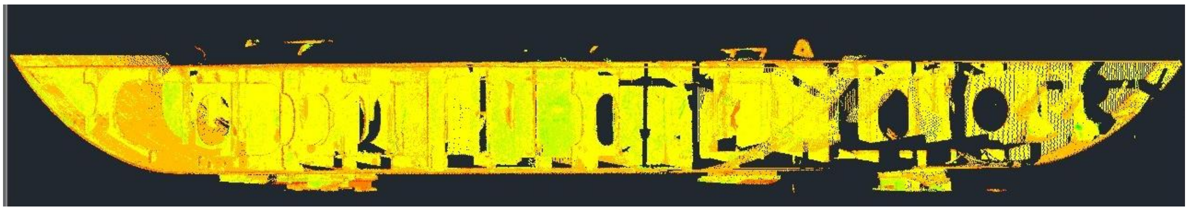
Figure 7. Section 116-01 of PSV 3300 E3 - Platform Supply Vessel

In pre-scanning stage there were materialized two stations chosen so that the part to be perfect framed between them. Visibility between the two stations was not necessary, because for registering scans taken from different stations are only required common points, edges or areas. To perform the scan task over the subassembly, the two points were stationed and there been used reflective targets particular for the scanner (Figure 8).

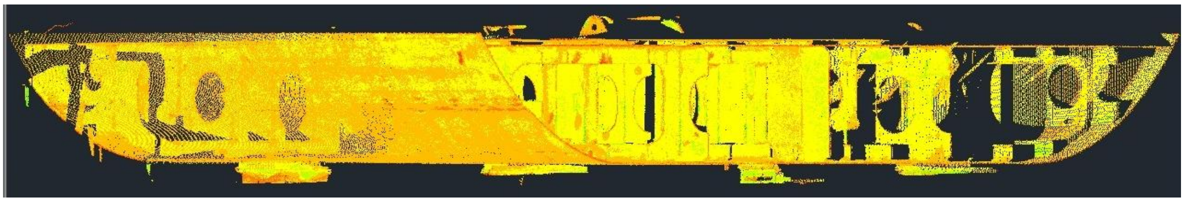
Figure 8. HDS Reflective targets

After the scanning phase, the registration process was performed, so that the 2 scans were introduced in a single reference system. This process is achieved by using pairs of objects that exist in both scans, called "constraints", in the present work - reflective targets. These constraints are recorded in the control space where they can be analyzed, organized and deleted but, not changed or resized.

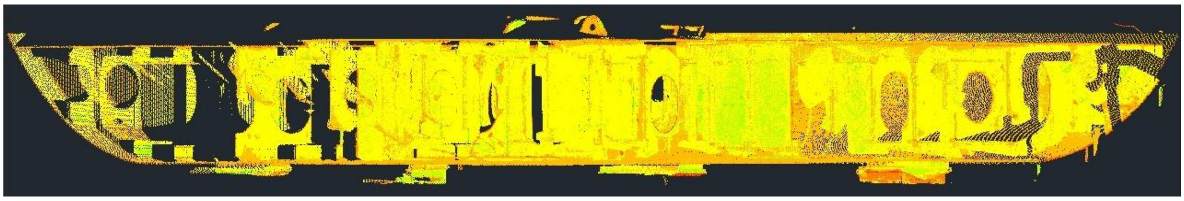
After completing of the registration process has been obtained the complete point cloud for scanned object (Figure 9).



a) Front view



b) Left view



c) Right view

Fig. 9. Registered point cloud for Section 116-01

The main purpose of a three-dimensional laser scanning is to obtain the digital model based on measurements made in the field. To achieve this goal is performed three-dimensional modeling of the registered and cleaned point cloud trough filtering data process. The program used for this is the same as for field data acquisition and their registration, Leica Cyclone but with Cyclone MODEL module, which have the proper interface and tools for point cloud transformation into a digital three-dimensional model under representation of geometric shapes of the unit.

The 3D model obtained for vessel unit can be used in the comparison with the data from the project and for extracting information regarding the actual size of the piece and three-dimensional coordinates of the points of interest obtained from measurements.

This information is necessary for the accuracy control in manufacturing processes and for creating the quality control report that intends to check the components (parts, sub-assemblies, etc.) geometry (shape, size, position of a component relative to another) and comparison with designed technical parameters.

4. Conclusions

3D laser scanning provides a lot of advantages such as: offers the possibility of comparing results with those original, it's fast and easy to use, accurate and non-destructive, very useful for areas that can not be measured by classical methods (with contact) and adaptive (can be used in combination with other measuring methods).

The data obtained through laser scanning technology are not reconstructed and interpreted by humans, representing the unchanged reality. Therefore, an important benefit of the technology is the ability of users to virtually return to the place of scan and to extract measurements and additional information.

Besides providing a quick solution to digitize real-world objects, laser scanning technology provides a complete set of data which is easy to interpret, due to, not only of point clouds, but also of recorded images. Also, performing one task may subsequently serve to conduct other operations without other field trips represents a plus in this branch of engineering fields.

The accuracy offered by the instrument is one of the best and is suitable for control work performed in shipbuilding industry if, taking into account the quality control requirements imposed for this domain.

However, in financial terms, this technique has the disadvantage represented by high costs of the equipment. However, in the future, these costs will slightly decrease with the evolution of technology, as in the case of IT, making possible the introduction to a larger scale of these instruments.

5. References

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